

**DUAL SIDE MOUNT SHOCK RESISTANT PIEZOELECTRIC BENDER**

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**Related Applications**

This application claims priority to U.S. Provisional Application Serial No.  
5 60/477,668 filed June 11, 2003, which is herein incorporated by reference.

**Field of the Invention**

This invention relates generally to the field of piezoelectric bender systems, and  
10 more particularly, but not by way of limitation, to a mounting assembly for use with a  
piezoelectric bender system.

**Background**

Piezoelectric transducers are often used in applications to create sounds in  
15 response to electric signals. Piezoelectric materials are used in sound generating  
applications due to low power consumption requirements, small space requirements, and  
readily available materials. These design advantages have led to applications in speakers,  
buzzers or other types of small sound generating units for portable and easily moveable  
systems.

20 These types of sound generating devices typically include some combination of a  
piezoelectric material, a thin metal diaphragm, an electrical circuit and a mounting  
device. The piezoelectric material and the metal diaphragm are usually bonded together  
and connected to the electrical circuit. Electrical activation of the piezoelectric material

causes it to alternately expand and contract, thereby translating electrical energy to mechanical energy. This movement of the piezoelectric material in turn bends the metal diaphragm to which it is bonded (hence the term “bender”), causing an acoustic wavefront that generates sound. The mounting device holds the piezoelectric material and the metal diaphragm (collectively the “bender”) in proper orientation to allow vibration of the bender while avoiding contact between the bender and other structures that may impede or attenuate the vibration.

One prior art method of mounting the bender is to affix a mounting ring to a single side of the bender. However, using a single mounting ring leaves the acoustic generating device susceptible to mechanical shock that can dislodge the bender from the mount, thereby causing a malfunction of the output. Also, the mount has a tendency to attenuate the sound generated by the bender and absorb some of the acoustic energy into the mounting adhesive, thereby decreasing the decibel level of the acoustic output.

Other prior art methods attempt to mount the bender on both the front and back surfaces using electrical conductors that provide electrical input. A bender mounted in this fashion is susceptible to lateral shock that can dislodge the bender from proper positioning on the mount and cause electronic failure. This method of mounting can also attenuate the sound below a desired magnitude required for a useful audible level due to a clamping action from the front and back mounts, thereby reducing the bender flexibility.

There is therefore a continued need for improving the capabilities of piezoelectric sounding devices. It is to these and other deficiencies in the prior art that the present invention is directed.

## **Summary of the Invention**

Preferred embodiments of the present invention provide an acoustic generating device that includes a piezoelectric material, a metal diaphragm, an electric circuit and mounting devices. The metal diaphragm is bonded to the piezoelectric material and has a nodal fulcrum. The electric circuit is connected to the piezoelectric material and electrically activates the piezoelectric material. The mounting devices are constructed of insulating material and are positioned at the top and bottom of the metal diaphragm. The mounting devices support the metal diaphragm at the nodal fulcrum with an adhesive.

## **Brief Description of the Drawings**

FIG. 1 is an elevational cross-sectional view of a piezoelectric bender.

FIG. 2 is an elevational view of the vibrational mode of the bender of FIG. 1.

FIG. 3 is a bottom view of the bender of FIG. 1.

FIG. 4 is a circuit diagram of a driver for use with the bender of FIG. 1.

FIG. 5 is an elevational cross-sectional view of an acoustic generating device constructed in accordance with a preferred embodiment of the present invention.

## **Detailed Description of the Preferred Embodiment**

In accordance with a preferred embodiment of the present invention, FIG. 1 shows an elevational view of a bender 100 for use as an acoustic generating device. A metal diaphragm 102, such as a thin metal plate, is attached to piezoelectric material 104 as known in the art. The metal diaphragm 102 is preferably constructed from brass,

stainless steel, or other suitable material. Likewise, the piezoelectric material 104 is constructed of a piezoelectric ceramic (such as lead, zirconate, titanate), but other materials that have piezoelectric properties are also suitable for use as an acoustic generating device. In addition to the embodiments disclosed herein, it is also assumed that the bender 100 could be constructed in a variety of shapes to match specific applications.

Referring now to FIG. 2, the metal diaphragm 102 is shown in a sound producing vibrational mode. When the piezoelectric material 104 (not shown in FIG. 2) is electrically activated, the metal diaphragm 102 enters the vibrational mode as indicated by the deflected metal diaphragm 102A, 102B. This alternating bending motion of the metal diaphragm 102 produces sound waves that generate the desired sound from the acoustic generating device. Also indicated in FIG. 2 are two nodal fulcrums (designated by F) that mark the points of minimal deflection for the metal diaphragm 102.

FIG. 3 is a bottom view of the bender 100 of FIG. 1. The bender 100 preferably includes electrical connectivity points A, B and C for use in electrically activating the bender 100 in accordance with techniques known in the art. The piezoelectric material 104 includes an input electrode 106 and feedback electrode 108, which are connected to electrical connectivity points A and B. The metal diaphragm 102 is connected to connectivity point C, as demonstrated further by FIG. 4.

Shown in FIG. 4 is an electric circuit 110 that provides an internal drive circuit for the bender 100. Nodes A, B and C correspond to electrical connectivity points A, B and C in the bender 100, and are typically soldered directly to those points to provide a reliable connection. Although the electric circuit 110 demonstrates a common circuit for

the activation of a piezoelectric material, the present invention is not so limited. Many other configurations are equally useful, such as push-pull circuits, and circuits that employ inverters, capacitors and inductors, any of which can provide the necessary excitation in the bender assembly 100 necessary to produce sound. The present invention  
5 can also be directly driven by logic level outputs from direct logic circuits or from a microprocessor.

Referring now to FIG. 5, shown therein is an acoustic generating device 111. The acoustic generating device 111 preferably includes a housing 112; the bender 100; the electric circuit 110 (not shown in FIG. 5); and mounting rings 114, 116. In a preferred  
10 embodiment, the housing 112 includes an aperture 113 that releases the sound produced by the bender 100. In an alternate embodiment, the housing 112 is substantially sealed.

Lower mounting ring 114 is provided below the bender 100 and is secured to the bottom side of the bender 100 using adhesive (such as glue, epoxy or other suitable adhesive) at the nodal fulcrums, designated as "F." It is preferable to secure the lower  
15 mounting ring 114 to the base 118 of the device 111 by molding the lower mounting ring into the housing 112 or by applying adhesive between the lower mounting ring 114 and the base 118. The lower mounting ring 114 is preferably constructed of plastic or other suitable insulator.

Similarly, upper mounting ring 116 is provided above the bender 100 and is  
20 secured to the top side of the bender 100 using adhesive at the nodal fulcrums, designated as "F." Preferably the upper mounting ring 116 is secured to the top 120 of the housing 112 by using adhesive between the upper mounting ring 116 and the top 120 or by

molding the upper mounting ring 116 into the housing 112. The upper mounting ring 116 is preferably constructed of plastic or other suitable insulator.

The nodal fulcrums are useful points by which the bender 100 can be mounted. Mounting at these points is beneficial for acoustic generating devices due to the limited attenuation that occurs, thereby allowing the device to function acoustically at an optimal level. Mounting at other points along the bender 100 tends to damp the vibration, thereby decreasing the sound generation capability of the device.

Placement of the upper and lower mounting rings 116, 114 as described above prevents vertical movement of the bender 100 that can dislodge the bender 100 from an opposing mounting ring. Also, the use of adhesive to attach either one or both the mounting rings 114, 116 to the bender 100 prevents lateral movement that can cause the bender 100 to become dislodged or to be moved from a position of support at the nodal fulcrum F. Maintaining the support of the bender 100 at the nodal fulcrum F prevents attenuation of the generated sound. It will be understood that the shape of the bender 100 dictates the shape of the mounting rings 114, 116.

Although the nodal fulcrum in FIG. 5 is shown to be on the metal diaphragm 102 at a location beyond the piezoelectric material 104, it is envisioned that the nodal fulcrum can occur at various points along the metal diaphragm 102. For example, the nodal fulcrum could be at the edges of the piezoelectric material 104, or even inside the outer radius of the piezoelectric material 104. In either case, the appropriate geometric mounting devices should support the bender 100 at the nodal fulcrum.

In accordance with one aspect of a preferred embodiment, the present invention provides an apparatus for protecting a bender assembly, thereby increasing the shock

resistance and operating life of the acoustic generating device. It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with details of the structure and functions of various embodiments of the invention, this disclosure is illustrative only, and changes may be made in detail, especially in matters of structure and arrangement of parts within the principles of the present invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed. It will be appreciated by those skilled in the art that the teachings of the present invention can be applied to other systems without departing from the scope and spirit of the present invention.